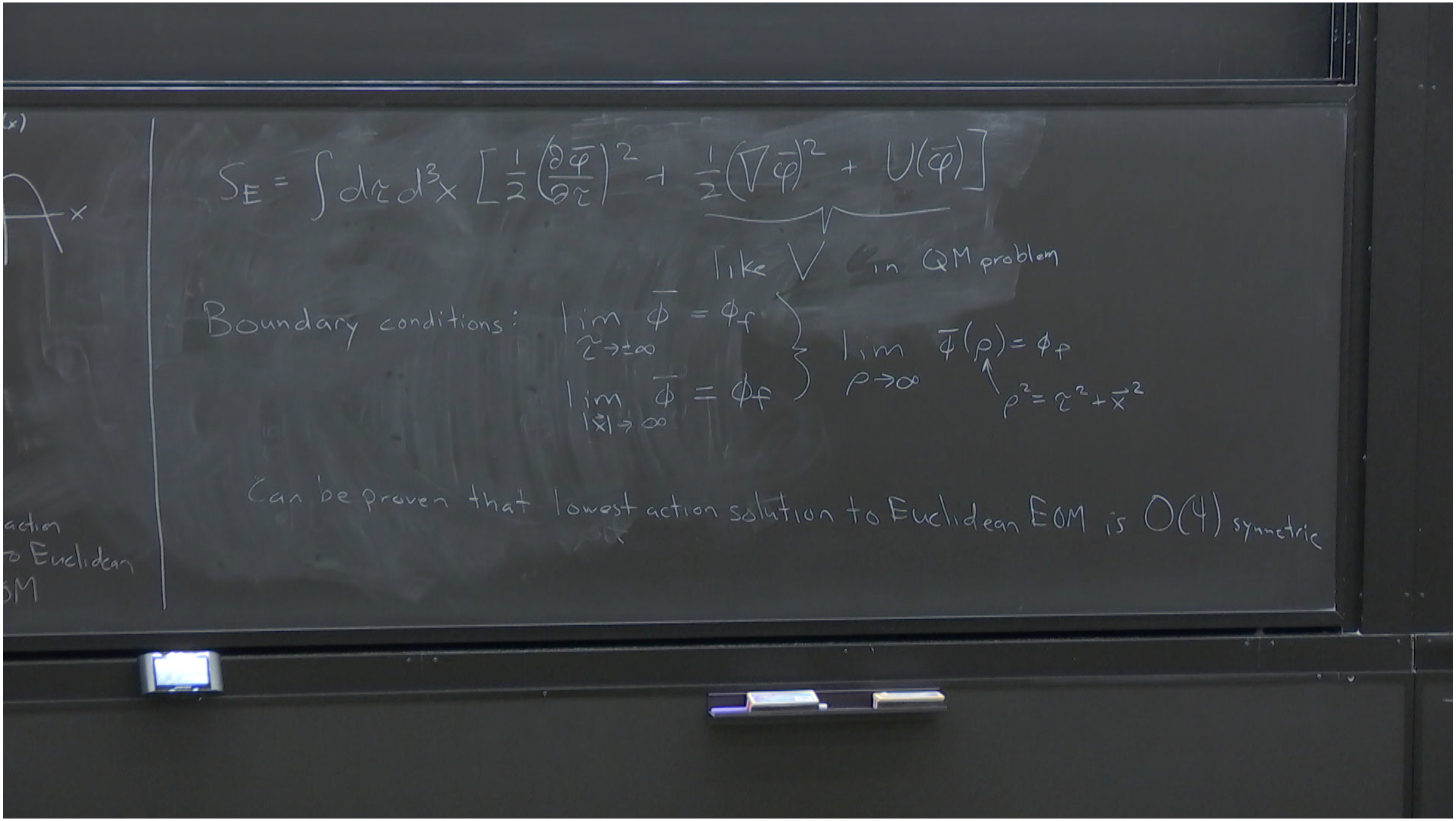
Title: PSI 2019/2020 - QFT III - Lecture 3

Speakers:

Collection: PSI 2019/2020 - QFT III

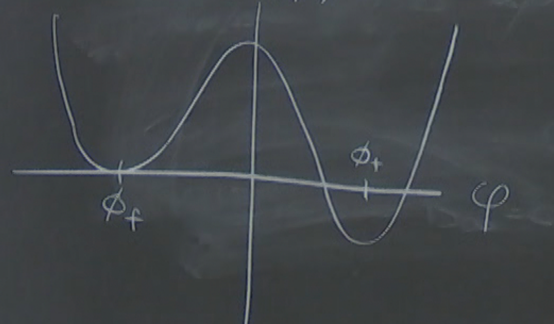
Date: January 15, 2020 - 11:30 AM

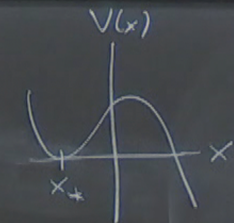
URL: http://pirsa.org/20010074


$S_E = \int d\tau\, d^3x \left[\frac{1}{2}\left(\frac{\partial\bar\varphi}{\partial\tau}\right)^2 + \underbrace{\frac{1}{2}(\nabla\bar\varphi)^2 + U(\bar\varphi)}_{\text{like } V \text{ in QM problem}} \right]$
Boundary conditions: $\lim_{\tau\to\pm\infty} \bar\phi = \phi_f$, $\lim_{|\vec{x}|\to\infty} \bar\phi = \phi_f$
$\lim_{\rho\to\infty} \bar\Phi(\rho) = \phi_f$
$\rho^2 = \tau^2 + \vec{x}^2$
Can be proven that lowest action solution to Euclidean EOM is O(4) symmetric
action
to Euclidean
EOM

Decay of False Vacua in QFT

② Vacua





$$\mathcal{L} = \frac{1}{2}\partial_\mu\varphi\,\partial^\mu\varphi - U(\varphi)$$

QFT as ∞ dim QM

$$\frac{\Gamma}{\mathrm{vol}} = A\, e^{-S_E[\bar{\phi}]/\hbar}$$

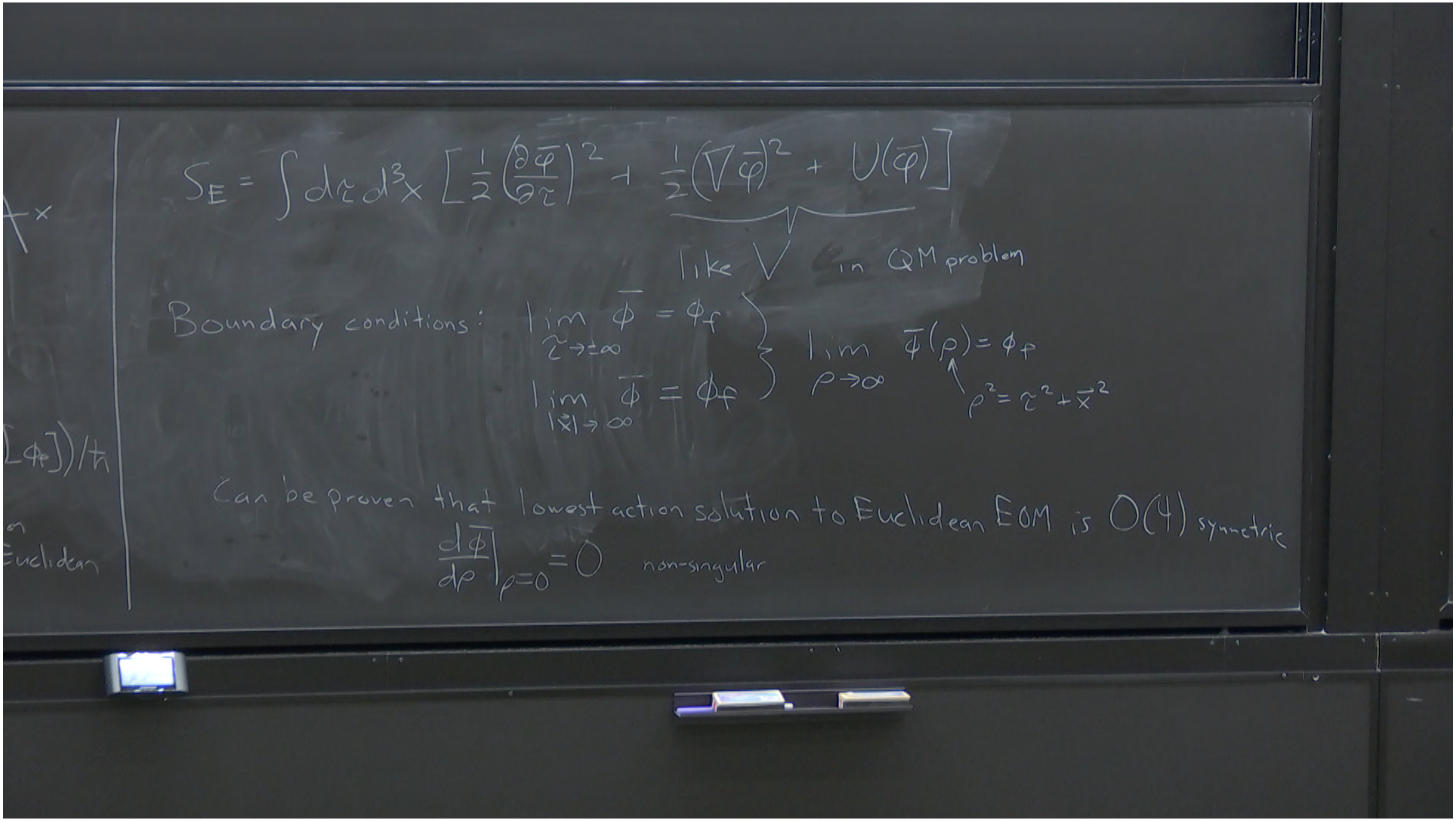
finite because decay is localized

$\propto \det{}' S''$

finite action soln to Euclidean EOM

$$\langle \varphi=\phi_f |\, e^{-HT/\hbar} \,| \varphi=\varphi_f \rangle = Z$$

$$E_0 = -\lim_{T\to\infty} \frac{\hbar}{T} \ln Z$$


$S_E = \int d\tau\, d^3x \left[\frac{1}{2}\left(\frac{\partial \bar{\varphi}}{\partial \tau}\right)^2 + \underbrace{\frac{1}{2}(\nabla \bar{\varphi})^2 + U(\bar{\varphi})}_{\text{like } V \text{ in QM problem}} \right]$
Boundary conditions: $\lim_{\tau \to \pm\infty} \bar{\phi} = \phi_f$
$\lim_{|\vec{x}| \to \infty} \bar{\phi} = \phi_f$
$\lim_{\rho \to \infty} \bar{\Phi}(\rho) = \phi_f$
$\rho^2 = \tau^2 + \vec{x}^2$
Can be proven that lowest action solution to Euclidean EOM is $O(4)$ symmetric
$\left.\frac{d\bar{\phi}}{d\rho}\right|_{\rho=0} = 0$ non-singular

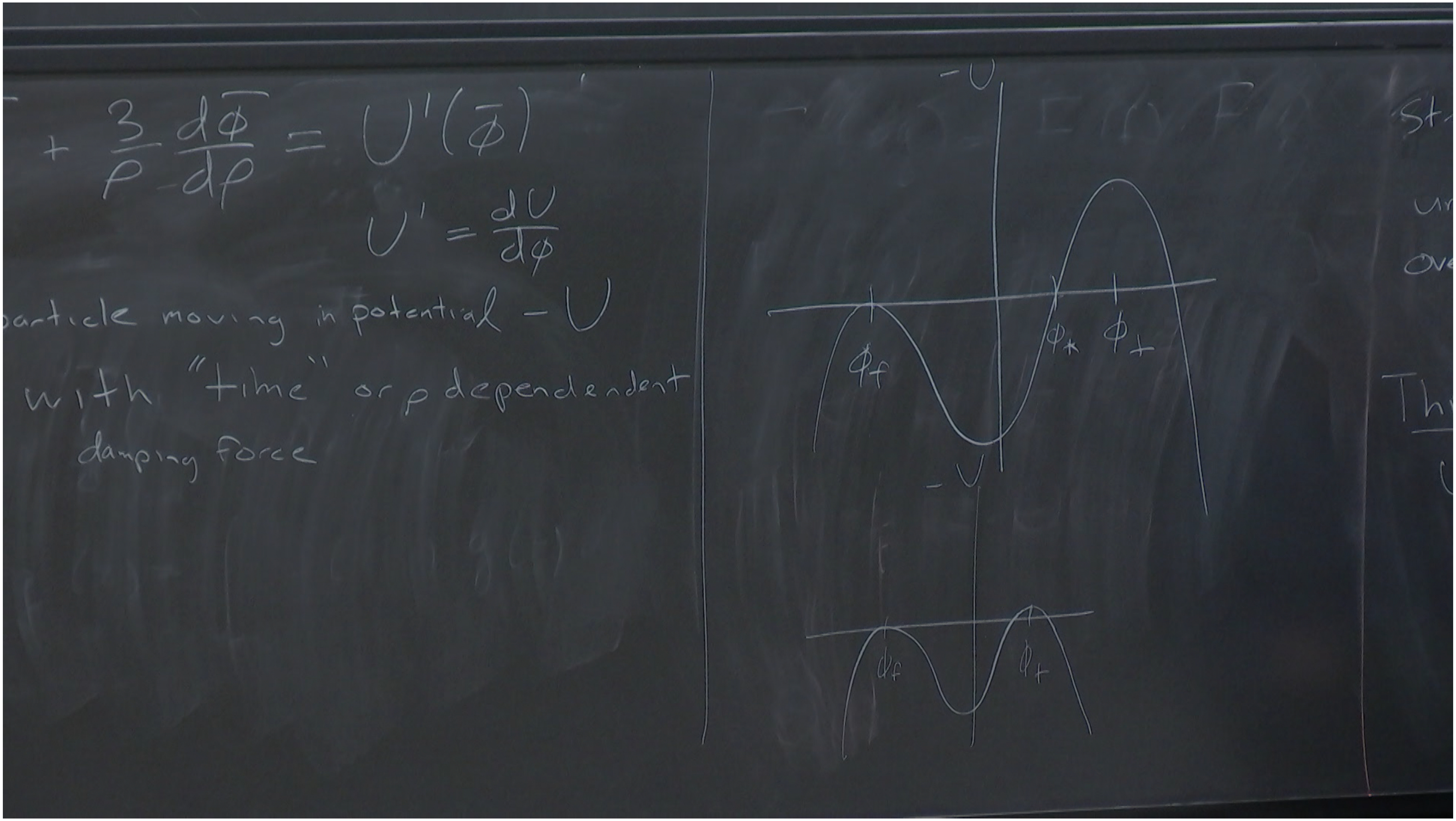
$$\text{EOM:}\quad \frac{d^2\bar{\Phi}}{d\rho^2} + \frac{3}{\rho}\frac{d\bar{\Phi}}{d\rho} = U'(\bar{\phi})$$

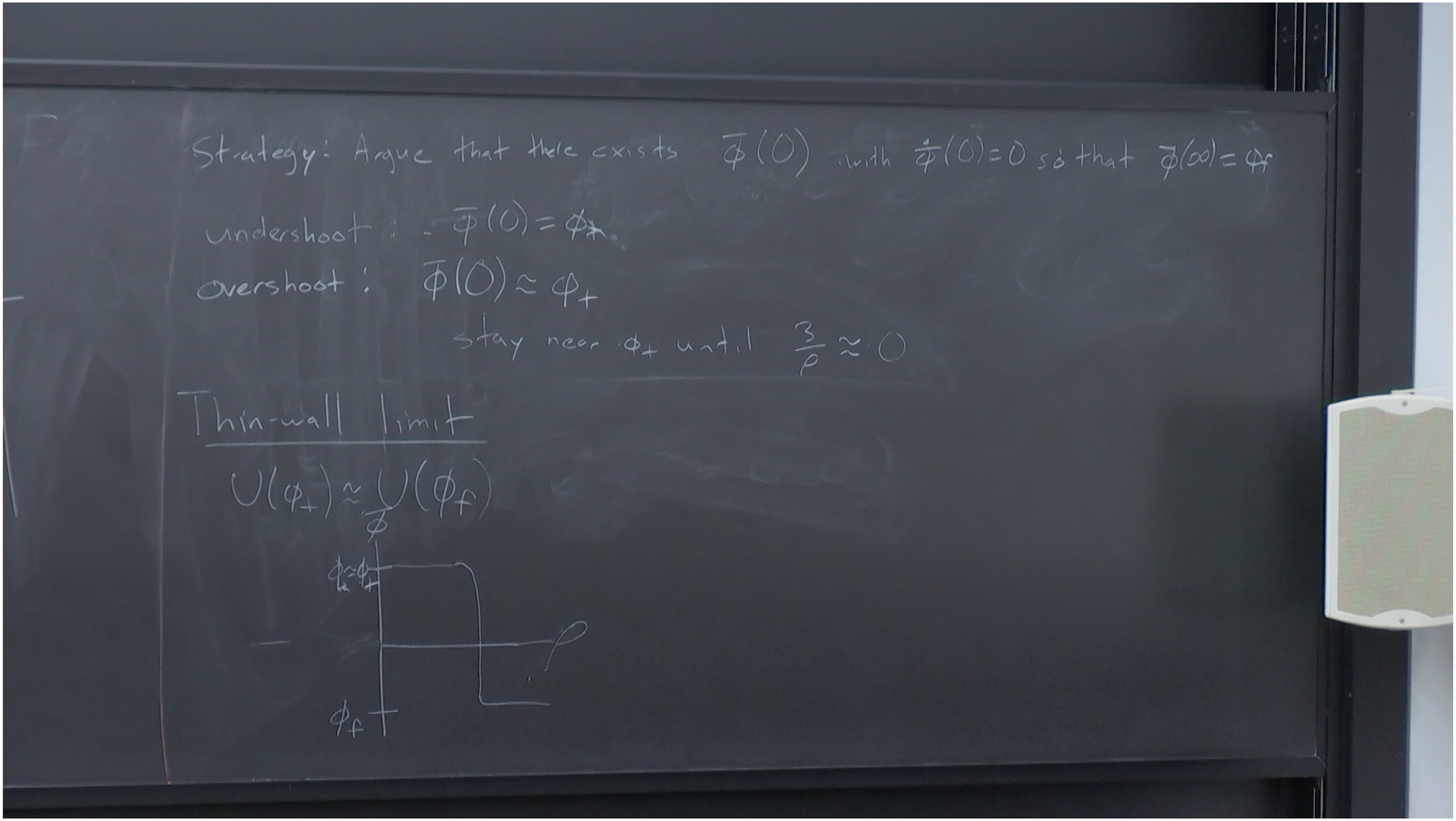
$$U' = \frac{dU}{d\phi}$$

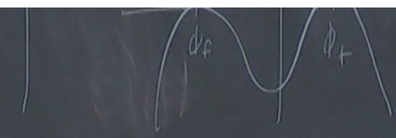
like a particle moving in potential $-U$

with "time" or ρ dependendent

damping force


$+ \frac{3}{\rho}\frac{d\bar{\phi}}{d\rho} = U'(\bar{\phi})$
$U' = \frac{dU}{d\phi}$
particle moving in potential $-U$
with "time" or ρ dependendent
damping force
$-U$
ϕ_f
ϕ_*
ϕ_+
$-U$
ϕ_f
ϕ_+


Strategy: Argue that there exists $\bar{\phi}(0)$ with $\dot{\bar{\phi}}(0)=0$ so that $\bar{\phi}(\infty)=\phi_f$
undershoot: $\bar{\phi}(0)=\phi_*$
overshoot: $\bar{\phi}(0)\simeq\phi_+$
stay near ϕ_+ until $\frac{3}{\rho}\approx 0$
Thin-wall limit
$U(\phi_+)\approx U(\phi_f)$
$\bar{\phi}$
$\phi_*\approx\phi_+$
ρ
ϕ_f



$$S_E = -\frac{1}{2}\pi^2 R_0^4 \epsilon + 2\pi^2 R_0^3 \sigma$$

volume term

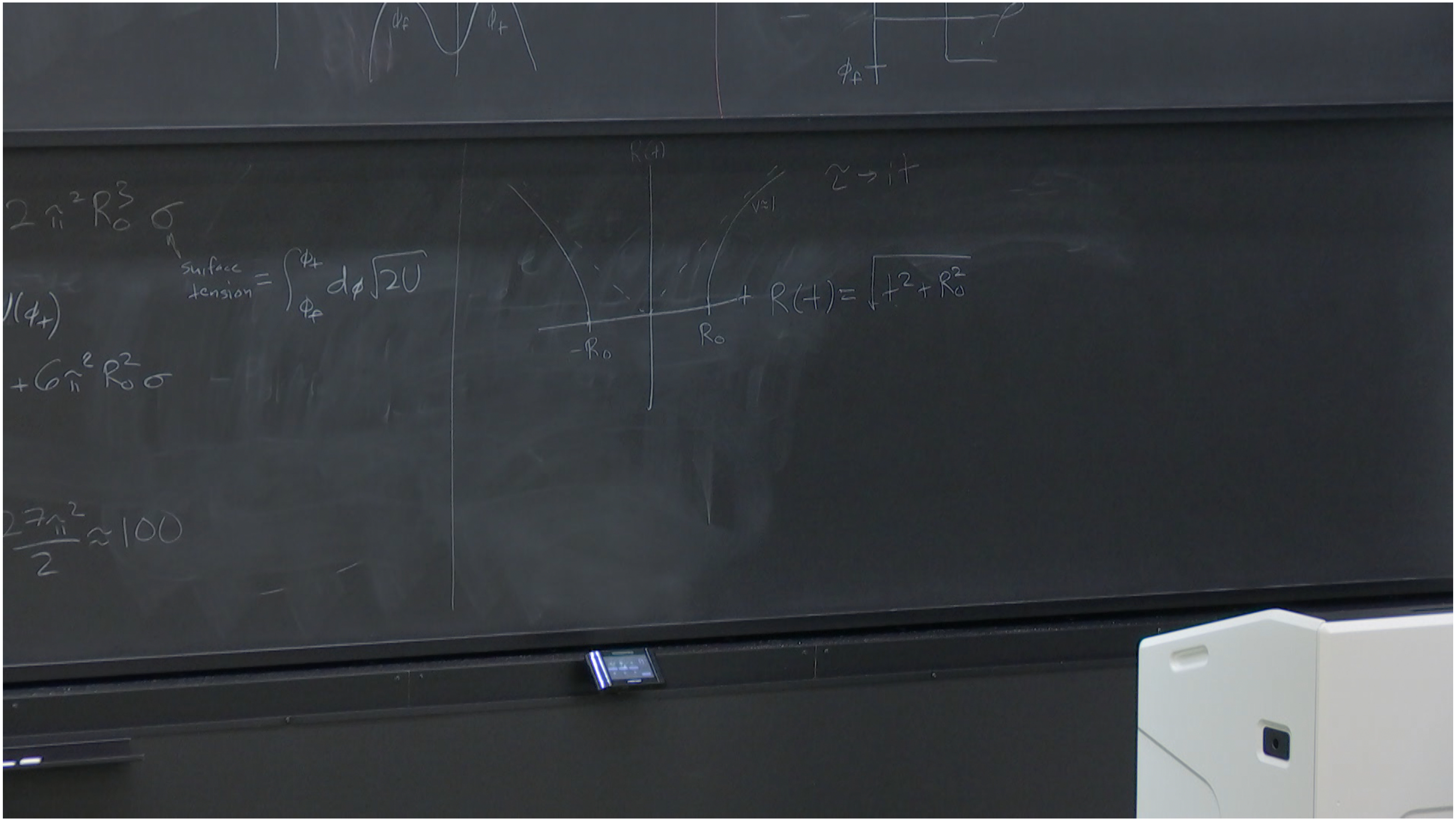
$U(\phi_f) - U(\phi_+)$

surface tension $= \int_{\phi_f}^{\phi_+} d\phi \sqrt{2U}$

$$\frac{dS_E}{dR_0} = 0 = -2\pi^2 R_0^3 \epsilon + 6\pi^2 R_0^2 \sigma$$

$$R_0 = \frac{3\sigma}{\epsilon}$$

$$S_E = \frac{27\pi^2\sigma^4}{2\epsilon^3} \qquad \frac{27\pi^2}{2} \approx 100$$


ϕ_f
ϕ_+
$2\pi^2 R_0^3 \sigma$
surface tension $= \int_{\phi_f}^{\phi_+} d\phi \sqrt{2U}$
$U(\phi_+)$
$+6\pi^2 R_0^2 \sigma$
$\frac{27\pi^2}{2} \approx 100$
$R(t)$
$v \approx 1$
$-R_0$
R_0
t
$R(t) = \sqrt{t^2 + R_0^2}$
$\tau \to it$

$E_0 = -\lim_{T\to\infty} \frac{\hbar}{T} \ln Z$

because decay is localized

EOM

Θ Vacua

Classical vacua of YM?

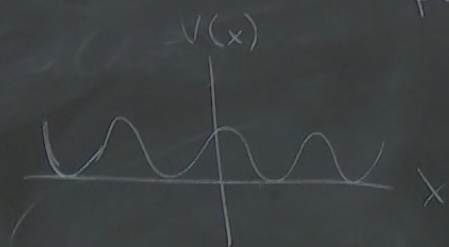
Expect: $A_\mu = 0 + i U \partial_\mu U^{-1}$

pure gauge

not deformable into one another restricting to pure gauge

$A_{1\mu} = i U_1 \partial_\mu U_1^{-1}$

$A_{2\mu} = i U_2 \partial_\mu U_2^{-1}$



$d\rho \,|_{\rho=0} = 0$ non-singular

$iU_1 \partial_\mu U_1^{-1}$

$iU_2 \partial_\mu U_2^{-1}$

$$S_E = \frac{1}{2g} \int d^4x \, \mathrm{tr} F_{\mu\nu} F^{\mu\nu}$$